(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 555 882 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **93102313.9**

(22) Date of filing: **15.02.93**

(51) Int. Cl.⁵: **B21B 1/24**, B21B 37/00

(30) Priority: **14.02.92 JP 27969/92**

(43) Date of publication of application:
18.08.93 Bulletin 93/33

(84) Designated Contracting States:
DE GB

(71) Applicant: **HITACHI, LTD.**
6, Kanda Surugadai 4-chome
Chiyoda-ku, Tokyo 101(JP)

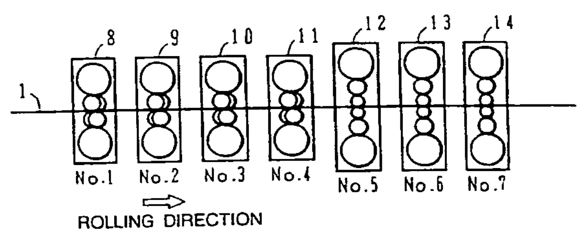
(72) Inventor: **Yasuda, Kenichi**
1181-80, Higashiishikawa
Katsuta-shi, Ibaraki-ken(JP)
Inventor: **Narita, Kenjiro**
32-3-402, Nishinarusawacho 1-chome
Hitachi-shi, Ibaraki-ken(JP)
Inventor: **Hirama, Yukio**
2151-16, Motoyoshidacho
Mito-shi, Ibaraki-ken(JP)
Inventor: **Satou, Kouji**
31-12, Aitacho 3-chome
Hitachi-shi, Ibaraki-ken(JP)
Inventor: **Yoshimura, Yasutsugu**
26-7, Nakanarusawacho 2-chome
Hitachi-shi, Ibaraki-ken(JP)
Inventor: **Takakura, Yoshio**
37-4, Nishinarusawacho 4-chome
Hitachi-shi, Ibaraki-ken(JP)
Inventor: **Kaga, Shinichi**
4-1-604, Nakanarusawacho 2-chome
Hitachi-shi, Ibaraki-ken(JP)

(74) Representative: **Patentanwälte Beetz sen. - Beetz jun. Timpe - Siegfried - Schmitt-Fumian**
Steinsdorfstrasse 10
D-80538 München (DE)

(54) **Tandem mill system and work roll crossing mill.**

(57) In a tandem mill system, at least one first type rolling mill is arranged in the upstream side and at least one second type rolling mill is arranged in the downstream side. The first type rolling mill is of the so-called work roll crossing mill in which a pair of work rolls are inclined with respect to a pair of back-up rolls supporting the work rolls and simultaneously crossed each other in a horizontal plane to control transverse thickness distribution of a strip. The second type rolling mill is of the so-called HC mill which controls the strip crown and shape by a combination of axial movement of intermediate rolls and work roll bending. Such an arrangement makes it possible to increase a capability of controlling the strip crown and shape, particularly, a capability of correcting the quarter buckle, and eliminate a fear of causing scratches on the strip and roll surfaces, with the result of improved production efficiency. Plural lines of lubricant supply device are also provided to stop supply of a lubricant immediately before biting of the strip into the work roll crossing mill and start the supply again after the biting. A system of lubricating the work roll crossing mill is thereby improved.

FIG. 1



EP 0 555 882 A1

Secondly, no considerations are paid to scratches of rolls due to strips. More specifically, in both hot and cold rolling, a strip-caused scratch occurs on the roll surface during the rolling. The occurrence of a strip-caused scratch on the roll surface deteriorates the surface quality of rolled products and hence requires replacement of rolls. In particular, if a strip-caused scratch occurs in any upstream roll, the scratch is transferred to downstream rolls as well and the number of rolls to be replaced is increased, thus leading to a large influence.

In the case of hot rolling, rolls are brought into contact with strips at high temperatures in several upstream stands and the roll surface inevitably changes in quality such that the so-called scale is created thereon. Taking the fact into account, it has been practiced to intentionally or positively deposit the scale as one kind of surface coating. The scale is very hard and no particular problems arise if it is uniformly deposited over the roll surface. However, deposition of the scale onto the roll surface is not so stable in its creation process immediately after roll replacement that the scale once deposited is often peeled off and caught up between the roll and the strip, thereby causing a scratch. Accordingly, roll replacement is required and time loss necessary for the roll replacement leads to a reduction in production efficiency. Moreover, the necessity of rolling those strips, which especially tend to create the scale, immediately after roll replacement has imposed limitations on the degree of freedom in schedule.

A first object of the present invention is to provide a tandem mill system which has a high capability of controlling the strip crown and shape, particularly, a high capability of correcting the quarter buckle, has a high rate of production, and is free from a fear of causing scratches on the strip and roll surfaces, by arranging work roll crossing mills in each of which a pair of work rolls are inclined with respect to associated back-up rolls and also crossed each other.

A second object of the present invention is to improve, in a system comprising a plurality of work roll crossing mills in each of which a pair of work rolls are inclined with respect to associated back-up rolls and also crossed each other, a manner of lubricating between the work rolls and the back-up rolls supporting the work rolls, thereby providing a tandem mill system which enables smooth lubrication.

A third object of the present invention is to improve, in a work roll crossing mill in which a pair of work rolls are inclined with respect to associated back-up rolls and also crossed each other, as well as a tandem mill system including a plurality of such work roll crossing mills, a manner of lubricating between the work rolls and the back-up rolls supporting the work rolls, thereby providing a tandem mill system and a work roll crossing mill which enable smooth lubrication.

To achieve the above first object, in accordance with the present invention, there is provided a tandem mill system in which a plurality of rolling mills are arranged along a rolling line, said plurality of rolling mills including (a) at least one first type rolling mill comprising a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to a pair of said back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip; and (b) at least one second type rolling mill having a shape control function of providing an influence upon a pattern of the transverse thickness distribution of said strip different from the influence provided by said first type rolling mill.

To achieve the above first object, in accordance with the present invention, there is also provided a tandem mill system in which a plurality of rolling mills are arranged along a rolling line, said plurality of rolling mills including (a) at least one first type rolling mill comprising a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other respective horizontal planes to control transverse thickness distribution of a strip; and (b) at least one second type rolling mill comprising a pair of work rolls and a pair of rolls movable in an axial direction, at least said pair of work rolls being applied with bending forces to control the transverse thickness distribution of said strip by a combination of the roll movement and the work roll bending.

To achieve the above first object, in accordance with the present invention, there is further provided a tandem mill system in which a plurality of rolling mills are arranged along a rolling line, said plurality of rolling mills including (a) at least one first type rolling mill comprising a pair of work rolls and a pair of back-up rolls, said pair of work rolls can be bended and being inclined or in line with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip; and (b) at least one second type rolling mill comprising a pair of bendably and a pair of bottle shaped rolls mutually symmetrical about a point and movable in an axial direction, said pair of bottle shaped rolls being moved in opposite directions to each other to control the transverse thickness distribution of said strip.

of work roll crossing mills each of which comprises a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to a pair of said back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip; (b) lubricant supply means provided for each of said plurality of work roll crossing mills for lubricating between said work rolls and said back-up rolls supporting said work rolls; (c) first detection means provided upstream of said plurality of work roll crossing mills for detecting the presence or absence of said strip; (d) second detection means provided for each of said plurality of work roll crossing mills for detecting biting of said strip; and (e) control means for controlling said lubricant supply means in response to signals from said first and second detection means.

To achieve the above second and third objects, in accordance with the present invention, there is provided a tandem mill system in which a plurality of rolling mills are arranged along a rolling line, comprising (a) said plurality of rolling mills including a plurality of work roll crossing mills each of which comprises a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip; and (b) plural lines of lubricant supply means provided for each of said plurality of work roll crossing mills for lubricating between said work rolls and said back-up rolls supporting said work rolls, said plural lines of lubricant supply means having respective lubricant supply sources per line.

To achieve the above third object, in accordance with the present invention, there is provided a work roll crossing mill comprising a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip, wherein said mill includes plural lines of lubricant supply means for lubricating between said work rolls and said back-up rolls supporting said work rolls, said plural lines of lubricant supply means having respective lubricant supply sources per line.

In the present invention concerned with the first object, the first type rolling mill is constituted by the so-called work roll crossing mill to control the transverse thickness distribution, i.e., the strip crown, ranged from the vicinity of the strip center based on its roll crossing effect, and the second type rolling mill has a shape control function to correct the transverse thickness distribution ranged from the vicinity of the strip ends, thereby exhibiting a high capability of quarter buckle control. Also, in the work roll crossing mill, since a cross angle of the work rolls can be controlled even during the rolling of the strip, during passing cross angle control is permitted.

In the work roll crossing mills used as the first type rolling mill, since the work rolls are rotated in such a condition that they, are inclined with respect to the back-up rolls supporting the work rolls, there occur slight slips between the work rolls and the back-up rolls, causing these rolls to grind each other. As a result, scratches due to the scale are not caused in hot rolling, and a fear of causing scratches on the roll surfaces is eliminated. Thus, the roll surfaces are always kept clean in either case.

Furthermore, since the first type rolling mill controls the transverse thickness distribution of the strip based on the roll crossing, large-diameter work rolls can used therein. Accordingly, when the present invention is applied to hot rolling, the work rolls are prevented from being heated up to high temperatures and deterioration of the roll material can be suppressed. In addition, the use of large-diameter work rolls can ensure positive biting of thick strips.

The rolling mill which controls the transverse thickness distribution of the strip by a combination of the roll movement and the work roll bending, and the rolling mill which controls the transverse thickness distribution of the strip by moving the bottle shaped rolls, mutually symmetrical about a point, in opposite directions to each other have shape control functions of giving influences, different from the influence given by the first type rolling mill, upon a pattern of the transverse thickness distribution of the strip, thus making it possible to correct the transverse thickness distribution ranged from the vicinity of the strip ends. Therefore, a capability of quarter buckle control can be developed by using any of the above rolling mills as the aforesaid second type rolling mill.

Between the case where the transverse thickness distribution of the strip is controlled by the work roll crossing mill based on a combination of the roll crossing and the work roll bending, and the case where the transverse thickness distribution of the strip is controlled by the so-called PC mill, in which the work rolls and the back-up rolls are crossed together each other, based on a combination of the roll crossing and the work roll bending, there occurs a difference in characteristics of the work roll bending, when the work roll diameter is small, due to different degrees of interference in detrimental contact portions between the work rolls and the back-up rolls. In other words, the work roll bending imposes a greater,influence upon the

can be reduced while providing required lubrication to the work roll crossing mill.

With such an arrangement that the plural lines of lubricant supply means each have a number of nozzles arranged along the roll axial direction in the first type rolling mill, and the lubricant supply sources for the plural lines of lubricant supply means contain lubricants with different densities, when the detected thrust forces becomes too large, the lubricant with higher different density can be supplied so as to prevent a trouble of roll seizure or the like due to excessive thrust forces and hence prolong the service life of the rolls.

Brief Description of the Drawings

Fig. 1 is a schematic view of a tandem mill system according to a first embodiment of the present invention.

Fig. 2 is a schematic view of a first type rolling mill (a work roll crossing mill) shown in Fig. 1.

Fig. 3 is a schematic view of a second rolling mill (an HC mill) shown in Fig. 1.

Fig. 4 is a front view, partly sectioned, of the work roll crossing mill shown in Fig. 2.

Fig. 5 is a top plan view, partly sectioned, of the work roll crossing mill shown in Fig. 4.

Fig. 6 is a schematic view of a 6-high mill having modified rolls which is arranged in place of the HC mill shown in Fig. 1.

Fig. 7 is a schematic view of a 4-high mill having modified rolls which is arranged in place of the HC mill shown in Fig. 1.

Fig. 8 is a schematic view of a tandem mill system according to a second embodiment of the present invention.

Fig. 9 is a schematic view of a tandem mill system according to a third embodiment of the present invention.

Fig. 10 is a schematic view of a tandem mill system according to a modification of the third embodiment shown in Fig. 9.

Fig 11 is a schematic view of a PC mill shown in Fig. 10.

Fig. 12 is a schematic view of a tandem mill system according to a fourth embodiment of the present invention.

Fig. 13 is a schematic view of a tandem mill system according to a fifth embodiment of the present invention.

Fig. 14 is a front view, partly sectioned, of a work roll crossing mill with a work roll bending function.

Fig. 15 is a top plan view, partly sectioned, of the work roll crossing mill shown in Fig. 14.

Fig. 16 is a view for explaining detrimental contact portions in roll bending.

Fig. 17 is a schematic view of a tandem mill system according to a sixth embodiment of the present invention.

Fig. 18 is a schematic view of a tandem mill system according to a seventh embodiment of the present invention.

Fig. 19 is a schematic view of a tandem mill system according to an eighth embodiment of the present invention.

Fig. 20 is a schematic view of a work roll crossing mill according to a ninth embodiment of the present invention.

Fig. 21 is a view showing distribution of roll-to-roll friction forces in a rolling mill.

Fig. 22 is a schematic view of a crossing mill according to a tenth embodiment of the present invention.

Fig. 23 is a schematic view of a tandem mill system according to still another embodiment of the present invention.

Fig. 24 is a schematic view of a tandem mill system according to still another embodiment of the present invention.

Fig. 25 is a schematic view of a tandem mill system according to still another embodiment of the present invention.

Detailed Description of the Preferred Embodiments

First Embodiment

To begin with, a first embodiment of the present invention will be described with reference to Figs. 1 to 5. In this embodiment, the present invention is applied to hot rolling.

In Fig. 1, a tandem mill system of this embodiment is constructed such that first type rolling mills 8 to 11, each being shown in Fig. 2, are arranged in the upstream side of from first to fourth stands, and second type rolling mills 12 to 14, each being shown in Fig. 3, are arranged in the downstream side of from fifth to seventh stands. A strip 1 to be rolled is supplied from the entry side of the first type rolling mills 8 to 11 and successively rolled through the two types rolling mills, including the second type rolling mills 12 to 14, in tandem.

The first type rolling mills 8 to 11 each comprise, as shown in Fig. 2, a pair of upper and lower work rolls 2, 3 and a pair of upper and lower backup rolls 6, 7. The first type rolling mill is of a crossing mill that the pair of work rolls 2, 3 are inclined with respect to the pair of back-up rolls 6, 7 respectively supporting the work rolls 2, 3 and also crossed each other in respective horizontal planes to control the transverse thickness distribution, i.e., the strip crown. In this specification, such a crossing mill will be referred to as "a work roll crossing mill" case by case. Further, this work roll

217 provided on the movable block 216 engage projections 203a formed at an end of the work roll chock 203, whereby driving forces of the hydraulic cylinders 215, 215 are transmitted to the work roll chock 203 to move the work roll 2 or 3 in the axial direction.

It is needless to say that, though not shown, the above-mentioned control of axial movement of the work rolls 2, 3 is performed by a movement amount controller depending on rolling conditions.

Further, as shown in Figs. 4 and 5, lubricant supply nozzles 218 are disposed along the roll axis as a primary member of a lubricant supply device for supplying a lubricant to between the work rolls 2, 3 and the back-up rolls 6, 7. The position where the lubricant supply nozzle 218 is disposed is not necessarily limited to the illustrated location, and may be at any location so long as lubricating oil as a lubricant can be supplied to between both the rolls.

A roll grinder 220 is installed closely to the roll surface of each of the back-up rolls 6, 7 for grinding the roll surface during the rolling. A brush roller 221 and a cleaning nozzle 222 are also installed to remove the lubricating oil that has adhered onto the roll surface of each of the back-up rolls 6, 7.

In the work roll crossing mill of this embodiment, as mentioned above, the lubricant supply nozzle 218 is disposed along the roll axis for supplying a lubricant to between the work rolls 2, 3 and the back-up rolls 6, 7. This supply of the lubricant reduces the coefficients of friction between the work rolls 2, 3 and the back-up rolls 6, 7, makes smaller thrust forces produced on the work rolls because of only the work rolls being crossed, and further successfully enables easy change of the strip crown during the rolling while providing a high capability of strip crown control. As a result, there can be realized a 4-high mill of the type that only the work rolls are crossed each other. Incidentally, the detailed operation of this type 4-high mill is described in Japanese Patent Application No. 3-66007.

In addition, since the upper and lower work rolls 2, 3 are arranged so as to shift in the axial direction, the work rolls can be axially moved during the rolling operation, which enables dispersion of wear and hence schedule free rolling.

A description will now be given of operating advantages of this embodiment.

In usual rolling schedule, a reduction rate of the first stand is maximum. Accordingly, if the large strip crown is given in the first stand, it becomes difficult to correct that strip crown in the subsequent stands. Stated otherwise, those rolling mills which have a high capability of correcting the strip crown are required to be installed in the upstream side including the first stand. In the case of hot rolling, since rolls are brought into contact with strips at high temperatures in several upstream stands, small-diameter rolls are heated up to high temperatures soon because of their small heat capacity and the quality of roll material is deteriorated. Also, if work rolls of upstream stands have a small diameter, those work rolls cannot bite a thick strip therebetween. For that reason, large-diameter work rolls are required in upstream stands of the tandem mill system. A 6-high UC or HC mill having large-diameter work rolls, however, becomes an extremely large-sized apparatus and increases the construction cost. Still another drawback is in that because of being less susceptible to bending, large-diameter work rolls have a small roll bending effect and hence exhibit a small capability of controlling the strip crown and so forth.

Furthermore, in the case of hot rolling, rolls are brought into contact with strips at high temperatures in several upstream stands and the roll surface inevitably changes in quality such that the so-called scale is created thereon. Taking the fact into account, it has been practiced to intentionally or positively deposit the scale as one kind of surface coating. The scale is very hard and no particular problems arise if it is uniformly deposited over the roll surface. However, deposition of the scale onto the roll surface is not so stable in its creation process immediately after roll replacement that the scale once deposited is often peeled off and caught up between the roll and the strip, thereby causing a scratch. Accordingly, roll replacement is required and time loss necessary for the roll replacement leads to a reduction in production efficiency. Moreover, the necessity of rolling those strips, which especially tend to create the scale, immediately after roll replacement has imposed limitations on the degree of freedom in schedule.

On the other hand, in the downstream stands where the strip thickness is small, a transverse deformation at the strip ends is small and flatness at the strip ends becomes a critical factor. Therefore, those rolling mills which have a high capability of correcting the strip end shape are required to be installed in the downstream stands.

In this embodiment, the work roll crossing mills are used as the first type rolling mills 8 to 11 arranged in the upstream side of the tandem mill system and their roll crossing effects are utilized to control the transverse thickness distribution, i.e., the strip crown, ranged from the vicinity of the strip center. In this connection, since the work roll crossing mill can control the cross angle during the rolling, it is possible to control the strip crown in real time while detecting the strip shape. The HC and/or UC mills are used as the second type rolling mills 12 to 14 arranged in the downstream side to concentrically correct the strip end shape based on

bility of correcting the strip end shape is required to be installed in the final stand. No particular problems arise even with conventional rolling mills used in the intermediate stands.

This embodiment is on the basis of the above consideration. More specifically, the work roll crossing mill and the HC mill are arranged in the first stand and the final seventh stand, respectively, so that the first stand controls the t ansverse thickness distribution, i.e, the strip crown, ranged from the vicinity of the strip center based on the roll crossing effect and the final stand concentrically corrects the strip end shape based on both the roll movement and the work roll bending, thereby making it possible to develop a high capability of quarter buckle control. This embodiment can also provide the similar advantages to those in the embodiment of Fig. 1 such as that the work roll crossing mill in the first stand causes no scratches on the roll and strips. Additionally, this embodiment can also be applied to cold rolling with the result of the similar advantages in relation to a capability of quarter buckle control and a reduction in the occurrence of scratches.

Third Embodiment

A third embodiment of the present invention will be described with reference to Fig. 9. This embodiment also represents the case where the present invention is applied to hot rolling. In this embodiment, the work roll crossing mills, each being shown in Fig. 2, are arranged as the first type rolling mills 10, 11 in the upstream third and fourth stands, the HC mills, each being shown in Fig. 3, are arranged as the second type rolling mills 12 to 14 in the downstream fifth to seventh stands, and conventional 4-high mills 8B, 9B with no rolls crossed are arranged in the upstream first and second stands.

As mentioned before, the scale deposits on the work rolls in the upstream stands. If the scale deposits uniformly in the axial direction, no particular problems arise; on the contrary, it is rather preferable in many cases. The scale is a hard metal oxide and has advantageous features such as high wear resistance. Therefore, the first and second stands in which the scale is more likely to deposit on the work rolls are constituted by the conventional 4-high mills, with an intention of positively depositing the scale to improve wear resistance. From the third stand in which deposition of the scale tends to be unstable, the work roll crossing mills, each being shown in Fig. 2, are arranged until the fourth stand so that the occurrence of roll scratches is prevented by utilizing the grinding effect based on the roll crossing.

A reduction in capability of strip crown control caused by the conventional 4-high mills 8B, 9B arranged in the first and second stands is compensated for by the work roll crossing mills 10, 11 in the third and fourth stands. As a result, a high capability of strip crown control can be developed through the entirety of the upstream first to fourth stands.

Consequently, this embodiment can also provide the similar advantages to those in the foregoing embodiments.

In the above-mentioned third embodiment, the first and second stands may be constituted by rolling mills of the type that pairs of work rolls and back-up rolls, one pair being on each of the upper and lower sides, are crossed together each other in respective horizontal planes, i.e., PC mills, other than the conventional 4-high mills. This alternative arrangement is shown in Fig. 10. In Fig. 10, PC mills 8D, 9D are arranged in the first and second stands. As shown in Fig. 11, the PC mills each comprise a pair of work rolls 2d, 3d and a pair of back-up rolls 6d, 7d arranged such that the pair of work rolls 2d, 3d and the pair of back-up rolls 6d, 7d supporting the work rolls 2d, 3d are crossed together each other in respective horizontal planes, thus controlling the transverse thickness distribution of the strip. The arrangement of Fig. 10 using the PC mills can also provide the similar advantages to those in the third embodiment.

Fourth Embodiment

A fourth embodiment of the present invention will be described with reference to Fig. 12. This embodiment represents an arrangement which is primarily used in cold rolling. In this embodiment, the work roll crossing mill shown in Fig. 2 is arranged as the first type rolling mill 11 in the fourth stand before the final stand, the HC mill shown in Fig. 3 is arranged as the second type rolling mill 12 in the final fifth stand, and conventional 4-high mills 86 to 10C with no rolls crossed are arranged in the upstream first to third stands.

In cold rolling, a capability of correcting the shape (flatness) is required rather than a capability of correcting the strip crown. For strips of large width, particularly, there is needed a capability of correcting the quarter buckle including not only simple end and middle elongations, but also mixture of these elongations. As mentioned before, such a capability is provided by properly combining a means which gives an influence upon the transverse thickness distribution pattern ranged from the vicinity of the strip enter and a means which concentrically applies an effect to the strip ends. The shape of final rolled products is greatly influenced by the final n-th stand (the fifth stand in

In this embodiment of Fig. 17, therefore, the first type rolling mills (work roll crossing mills) 8 to 11 shown in Fig. 1 are associated with a lubricant supply device which comprises valves 15 to 18, nozzles 100 to 107, a tank 38 as a supply source of the lubricant, and a pump 39. The valves 15 to 18 of the lubricant supply device are controlled by supply amount adjusters 22 to 25 and a controller 30. A strip sensor 29 is provided in the entrance side of a train of the rolling mills to detect the presence or absence of the strip 1. The presence of the strip is usually detected by using a thermometer. Further, load cells 31 to 34 are provided in the respective stands to detect biting of the strip.

When the strip sensor 29 detects that the strip has entered, a detected signal is taken by the controller 30 from which a supply stop signal is immediately transmitted to the supply amount adjuster 22 for the first stand. Threading speeds for the respective stands are previously input in the controller 30 which calculates periods of time required for the strip to pass the stand-to-stand distances and successively transmits supply stop signals to the supply amount adjusters for the subsequent stands with lags corresponding to the calculated periods of time. Meanwhile, the supply of the lubricant must be started again immediately after biting of the strip. To this end, the biting is detected by the load cells 31 to 34 provided on the respective stands, whereupon supply start signals are output to the supply amount adjusters 22 to 25. The lubricant is sent from the tank 38 as a supply source by the pump 39. By so controlling the supply of the lubricant, troubles due to excessive thrust forces and slip troubles at the time of biting are eliminated, with the result of improved production efficiency.

Seventh Embodiment

A seventh embodiment of the present invention will be described with reference to Fig. 18. This embodiment is also related to a lubricant supply device as with the above sixth embodiment. Generally, rolling schedule is determined so that rolling power becomes uniform throughout all the stands. Therefore, rolling load is not always on the same order in all the stands. There is such a tendency that rolling load is large in the upstream stands corresponding to a slow threading speed and, to the contrary, it is small in the downstream stands. Because thrust forces produced in the work roll crossing mill are almost proportional to rolling load, the upstream stands undergo larger thrust forces than the downstream stands and require more frequent replacement of the rolls and bearings, meaning that maintenance time has been wasted. This disadvantage can be eliminated by using, in the upstream stands, a lubricant with a greater capability of reducing the friction force than that of a lubricant used in the downstream stands.

In this embodiment of Fig. 18, therefore, the first type rolling mills (work roll crossing mills) 8 to 11 are divided into two groups and, correspondingly to these groups, the lubricant supply device is also divided into two groups. A lubricant with a greater capability of reducing the friction force or a lubricant with higher density is supplied to the first group of upstream work roll crossing mills 8, 9 from a tank 42 by a pump 43, whereas a different lubricant, i.e., a lubricant with a smaller capability of reducing the friction force or a lubricant with lower density is supplied to the second group of upstream work roll crossing mills 10, 11 from a tank 40 by a pump 41. By so supplying two kinds of lubricants, it is possible to make the thrust forces uniform in all the stands, cut down the time wastefully consumed, and hence improve production efficiency. Further, the amount of lubricant used is diminished.

Eighth Embodiment

An eighth embodiment of the present invention will be described with reference to Fig 19. This embodiment is also related to a lubricant supply device. In the above embodiments, the same lubricant is supplied to the upper and lower rolls. In many usual cases, however, roll lubricating conditions are different between the upper and lower sides, and roll wears are also different between the upper and lower sides. Generally, since a large amount of cooling water is used in hot rolling, the lubricant is more easily washed away in the lower rolls. Therefore, the coefficient of friction in the lower side is increased and wears of the lower rolls become larger correspondingly.

In view of the above, a lubricant supply system is divided into two lines between the upper rolls and the lower rolls of the rolling mills for supplying lubricants with different densities therethrough. In this embodiment of Fig. 19, valves 44 to 47 and the nozzles 100, 102, 104, 106 are provided as a device for supplying a lubricant to the upper rolls, whereas the valves 15 to 18 and the nozzles 101, 103, 105, 107 are provided as a device for supplying a lubricant to the lower rolls. The lubricant for the upper rolls is supplied to the upper roll system from a tank 51 by a pump 52, and the lubricant with higher density than the lubricant for the upper rolls is supplied to the lower roll system from the tank 38 by the pump 39. By so arranging, it is possible to prevent abnormal wear of the lower rolls, cut down the time wastefully consumed for roll replacement, and hence improve production efficiency.

to stop supply of the lubricant immediately before biting of the strip and start the supply again after the biting.

In this embodiment of Fig. 23, therefore, the first type rolling mills (work roll crossing mills) 8 to 11 and the second type rolling mills (work roll crossing mills) 12D to 14D are associated with a lubricant supply device which comprises valves 15 to 21, nozzles 100 to 107 and 150 to 155, a tank 38 as a supply source of the lubricant, and a pump 39. The valves 15 to 21 of the lubricant supply device are controlled by supply amount adjusters 22 to 28 and a controller 30. A strip sensor 29 is provided in the entrance side of a train of the rolling mills to detect the presence or absence of the strip 1. The presence of the strip is usually detected by using a thermometer. Further, load cells 31 to 37 are provided in the respective stands to detect biting of the strip.

When the strip sensor 29 detects that the strip has entered, a detected signal is taken by the controller 30 from which a supply stop signal is immediately transmitted to the supply amount adjuster 22 for the first stand. Threading speeds for the respective stands are previously input in the controller 30 which calculates periods of time required for the strip to pass the stand-to-stand distances and successively transmits supply stop signals to the supply amount adjusters for the subsequent stands with lags corresponding to the calculated periods of time. Meanwhile, the supply of the lubricant must be started again immediately after biting of the strip. To this end, the biting is detected by the load cells 31 to 37 provided on the respective stands, whereupon supply start signals are output to the supply amount adjusters 22 to 28. The lubricant is sent from the tank 38 as a supply source by the pump 39. By so controlling the supply of the lubricant, troubles due to excessive thrust forces and slip troubles at the time of biting are eliminated, with the result of improved production efficiency.

Furthermore, rolling schedule is generally determined so that rolling power becomes uniform throughout all the stands. Therefore, rolling load is not always on the same order in all the stands. There is such a tendency that rolling load is large in the upstream stands corresponding to a slow threading speed and, to the contrary, it is small in the downstream stands. Because thrust forces produced in the work roll crossing mill are almost proportional to rolling load, the upstream stands undergo larger thrust forces than the downstream stands and require more frequent replacement of the rolls and bearings, meaning that maintenance time has been wasted. This disadvantage can be eliminated by using, in the upstream stands, a lubricant with a greater capability of reducing the friction force than that of a lubricant used in the downstream stands.

In this embodiment of Fig. 24, therefore, the first type rolling mills (work roll crossing mills) 8 to 11 and the second type rolling mills (work roll crossing mills) 12D to 14D are divided into three groups and, correspondingly to these groups, the lubricant supply device is also divided into three groups. A lubricant with the greatest capability of reducing the friction force or a lubricant with highest density is supplied to the first group of upstream work roll crossing mills 8, 9, 10 from a tank 42 by a pump 43, a different lubrication, i.e., a lubricant with a smaller capability of reducing the friction force or a lubricant with lower density is supplied to the second group of work roll crossing mills 11, 12D, 13D from a tank 40 by a pump 41, and further a lubricant with the smallest capability of reducing the friction force or a lubricant with lowest density is supplied to the third group of work roll crossing mills 14D from the tank 38 by the pump 39. By so supplying three kinds of lubricants, it is possible to make the thrust forces uniform in all the stands, cut down the time wastefully consumed, and hence improve production efficiency. Further, the amount of lubricant used is diminished.

Moreover, in the above embodiments of Figs. 23 and 24, the same lubricant is supplied to the upper and lower rolls. In many usual cases, however, roll lubricating conditions are different between the upper and lower sides, and roll wears are also different between the upper and lower sides. Generally, since a large amount of cooling water is used in hot rolling, the lubricant is more easily washed away in the lower rolls. Therefore, the coefficient of friction in the lower side is increased and wears of the lower rolls become larger correspondingly.

Taking the above into account, in this embodiment of Fig. 25, a lubricant supply system is divided into two lines between the upper rolls and the lower rolls of the rolling mills for supplying lubricants with different densities therethrough. More specifically, valves 44 to 50 and the nozzles 100, 102, 104, 106, 150, 152, 154 are provided as a device for supplying a lubricant to the upper rolls, whereas the valves 15 to 21 and the nozzles 101, 103, 105, 107, 151, 153, 155 are provided as a device for supplying a lubricant to the lower rolls. The lubricant for the upper rolls is supplied to the upper roll system from a tank 51 by a pump 52, and the lubricant with higher density than the lubricant for the upper rolls is supplied to the lower roll system from the tank 38 by the pump 39. By so arranging, it is possible to prevent abnormal wear of the lower rolls, cut down the time wastefully consumed for roll replacement, and hence improve

4. A tandem mill system in which a plurality of rolling mills are arranged along a rolling line, said plurality of rolling mills including:
(a) at least one first type rolling mill (8 to 11) comprising a pair of work rolls (2, 3) and a pair of back-up rolls (6, 7), said pair of work rolls (2, 3) being inclined with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes, said pair of work rolls (2, 3) being applied with bending forces to control transverse thickness distribution of a strip by a combination of the roll crossing and the work roll bending; and
(b) at least one second type rolling mill comprising a pair of work rolls (2d, 3d) and a pair of back-up rolls (6d, 7d), said pair of work rolls being crossed each other together with said pair of back-up rolls supporting said work rolls in respective horizontal planes, said pair of work rolls (2d, 3d) being applied with bending forces to control the transverse thickness distribution of said strip by a combination of the roll crossing and the work roll bending.

5. A tandem mill system according to any one of claims 1 to 4, wherein said first type rolling mill (8 to 11) is arranged in at least a head stand of said plurality of rolling mills.

6. A tandem mill system according to any one of claims 1 to 4, wherein said second type rolling mill (12 to 14) is arranged in at least a tail stand of said plurality of rolling mills.

7. A tandem mill system according to any one of claims 1 to 4, wherein said first type rolling mill (8 to 11) is arranged in a stand upstream of said second type rolling mill (12 to 14).

8. A tandem mill system according to any one of claims 1 to 4, wherein said first type rolling mill includes means (208, 209) for controlling a cross angle of said pair of work rolls (2, 3) during the rolling in which said strip (1) is passing said first type rolling mill.

9. A tandem mill system according to any one of claims 1 to 4, wherein said first type rolling mill (8 to 11) includes lubricant supply means (218, 222) for lubricating between said work rolls (2, 3) and said back-up rolls (6, 7) supporting said work rolls.

10. A tandem mill system according to any one of claims 1 to 4, further including:
(c) lubricant supply means (15 to 18, 100 to 107) provided for said first type rolling mill (8 to 11) for lubricating between said work rolls (2, 3) and said back-up rolls (6, 7) supporting said work rolls;
(d) first detection means (29) provided upstream of said first type rolling mill for detecting the presence or absence of said strip (1);
(e) second detection means (31 to 34) provided for said first type rolling mill for detecting biting of said strip; and
(f) control means (30) for controlling said lubricant supply means in response to signals from said first and second detection means.

11. A tandem mill system according to any one of claims 1 to 4, further including:
(c) plural lines of lubricant supply means (41, 43) provided for said first type rolling mill (8 to 11) for lubricating between said work rolls (2, 3) and said back-up rolls (6, 7) supporting said work rolls, said plural lines of lubricant supply means having respective lubricant supply sources (41, 43) per line.

12. A tandem mill system according to claim 11, wherein said first type rolling mill is provided plural in number, said plural first type rolling mills are divided into plural groups in the direction of movement of said strip, and said plural lines of lubricant supply means are divided into plural lines corresponding to the plural groups of said first type rolling mills.

13. A tandem mill system according to claim 12, wherein out of said plural lines of lubricant supply means, the line corresponding to the upstream group (8, 9) of said first type rolling mills (8 to 11) has said lubricant supply course (42, 43) containing a lubricant with higher density, and the line corresponding to the downstream group (10, 11) of said first type rolling mills (8 to 11) has said lubricant supply source (40, 41) containing a lubricant with lower density.

14. A tandem mill system according to claim 11, wherein said plural lines of lubricant supply means (38, 39; 51, 52) are divided into two lines corresponding to the upper rolls (2, 6) and the lower rolls (3, 7) of said first type rolling mill.

15. A tandem mill system according to claim 14, wherein out of said two lines of lubricant supply means, the line corresponding to said up-

24. A tandem mill system according to claim 23, wherein out of said two lines of lubricant supply means, the line corresponding to said upper rolls has said lubricant supply source containing a lubricant with higher density, and the line corresponding to said lower rolls has said lubricant supply source containing a lubricant with lower density.

25. A tandem mill system according to claim 20, wherein said plural lines of lubricant supply means have a number of nozzles arranged along a roll axial direction in each of said work roll crossing mills, said number of nozzles are divided into plural groups (110 to 115) in the roll axial direction, and said plural lines of lubricant supply means are divided into plural lines corresponding to the plural groups of said nozzles.

26. A tandem mill system according to claim 25, wherein out of said plural lines of lubricant supply means, the line corresponding to the nozzle group (110, 113) in a roll central portion has said lubricant supply source containing a lubricant with higher density, and the line corresponding to the nozzle group in a roll end portion has said lubricant supply source containing a lubricant with lower density.

27. A tandem mill system according to claim 20, wherein said plural lines of lubricant supply means each have a, number of nozzles arranged along a roll axial direction in each of said work roll crossing mills, and said lubricant supply sources for said plural lines of lubricant supply means contain lubricants with different densities.

28. A work roll crossing mill comprising a pair of work rolls and a pair of back-up rolls, said pair of work rolls being inclined with respect to said pair of back-up rolls supporting said work rolls and simultaneously crossed each other in respective horizontal planes to control transverse thickness distribution of a strip, wherein: said mill includes plural lines of lubricant supply means for lubricating between said work rolls and said back-up rolls supporting said work rolls, said plural lines of lubricant supply means having respective lubricant supply sources per line.

FIG. 2

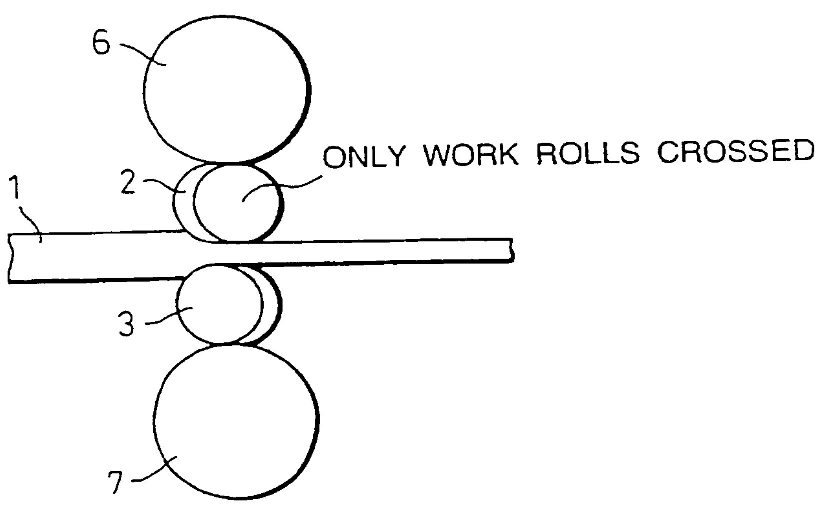


FIG. 4

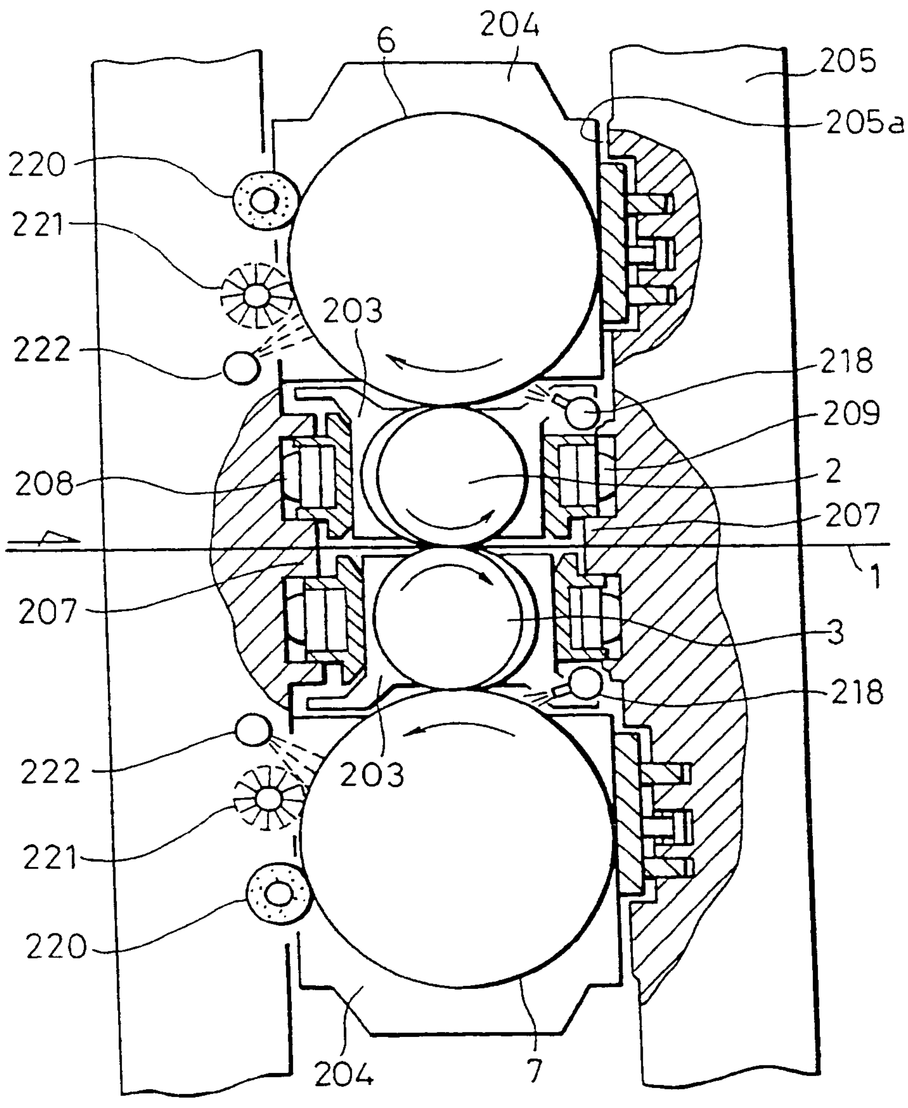

6
204
205
205a
220
221
203
222
218
209
208
2
207
1
207
3
218
222
203
221
220
204
7

FIG.6

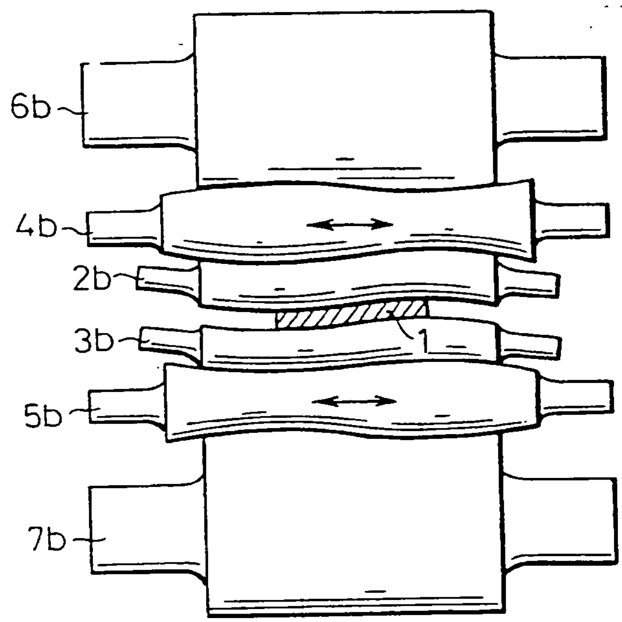


FIG.7

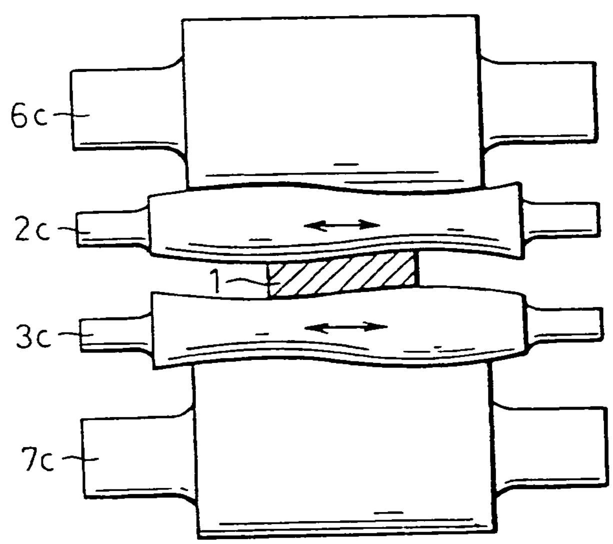


FIG.11

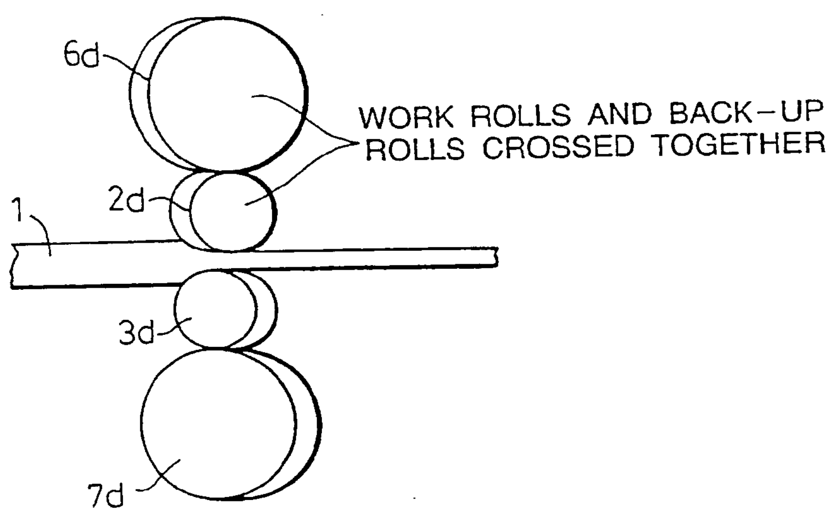


FIG.14

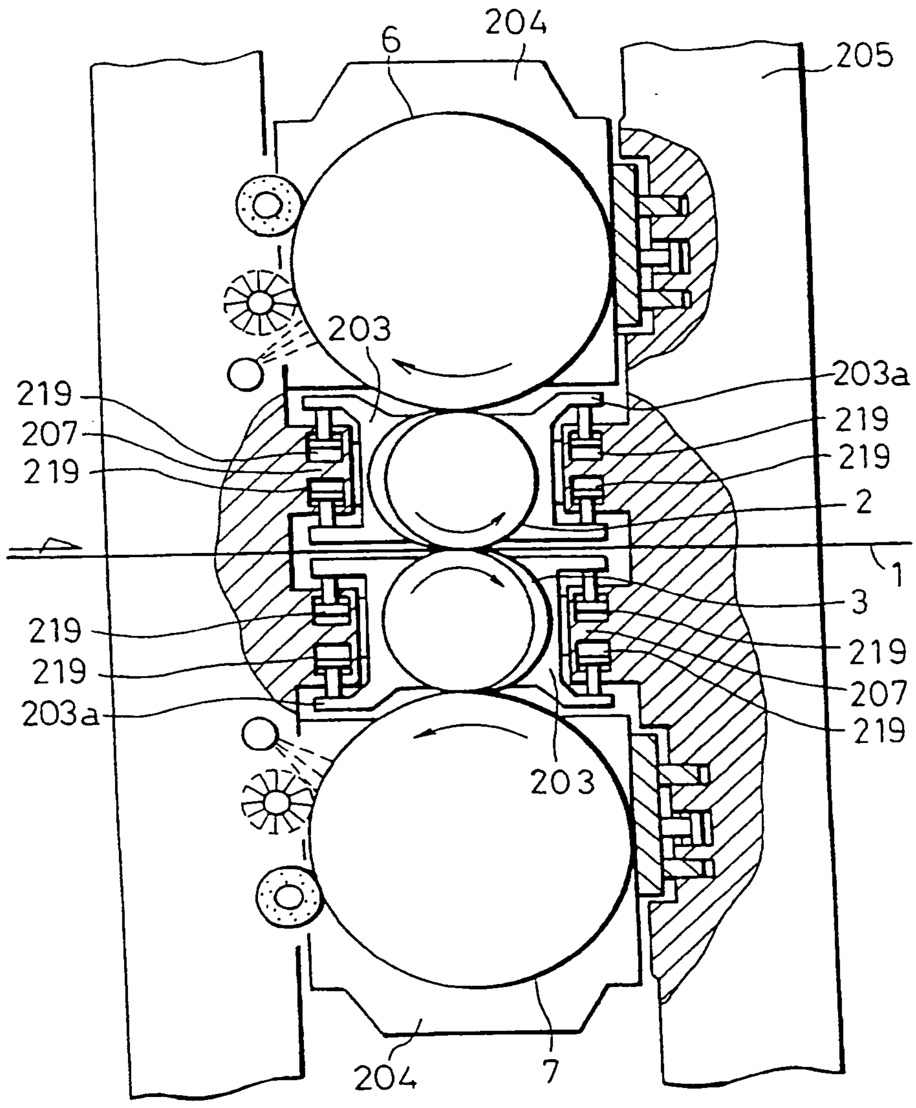
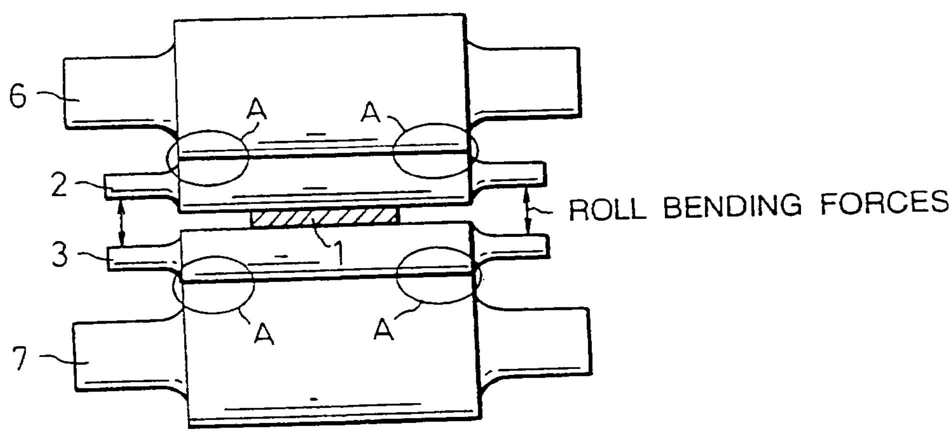

6
204
205
203
203a
219
207
219
2
1
3
219
219
203a
219
207
219
203
204
7

FIG. 16



A:DETRIMENTAL CONTACT PORTIONS
WHERE BENDING DEFORMATION OF
WORK ROLLS DUE TO ROLL BENDEING
FORCES IS IMPEDED

FIG.18

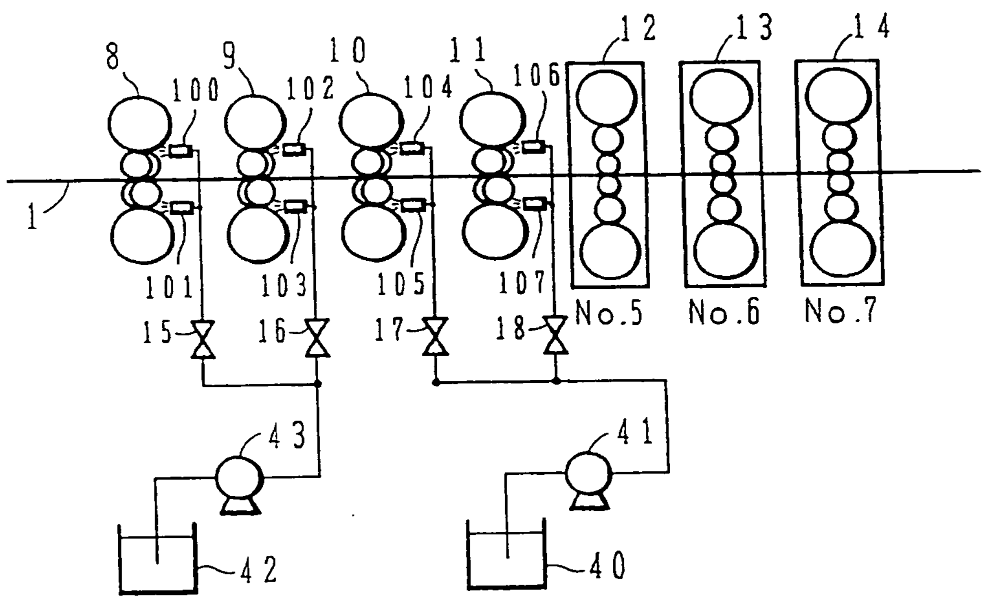

8
9
10
11
12
13
14
100
102
104
106
1
101
103
105
107
15
16
17
18
No.5
No.6
No.7
43
41
42
40

FIG.20

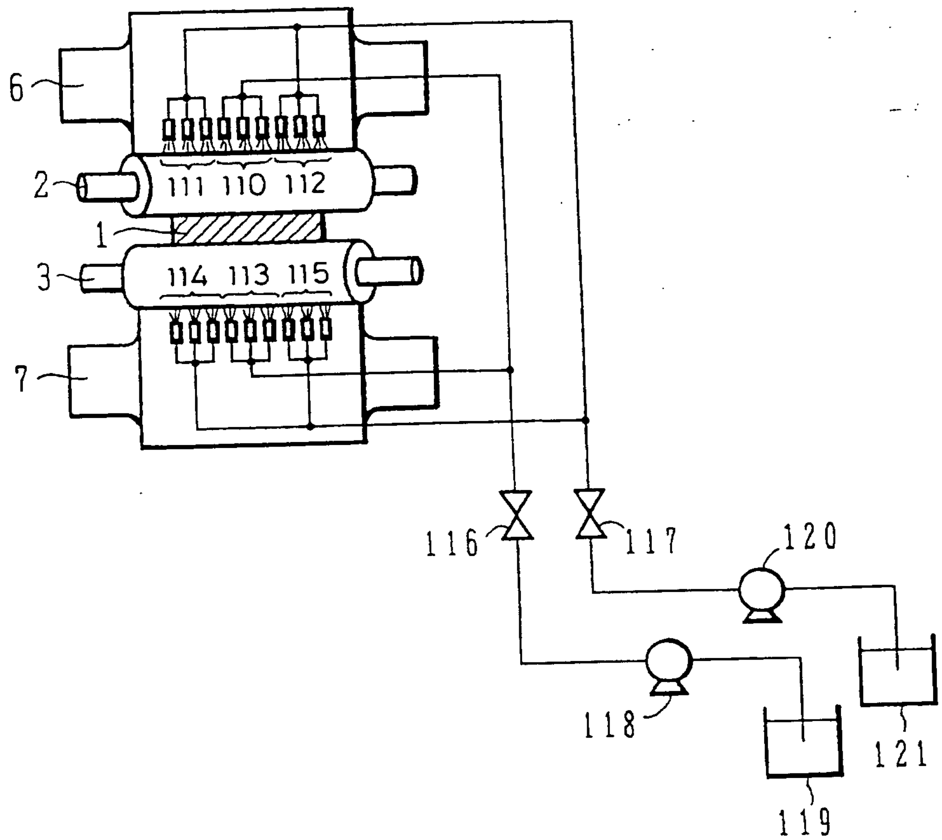

6
2
1
3
7
111 110 112
114 113 115
116
117
120
118
119
121

FIG.21

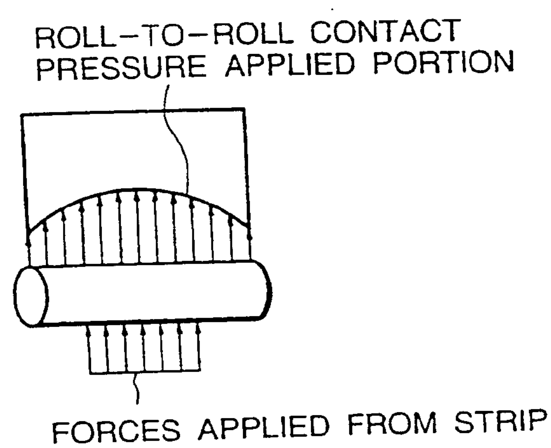

ROLL-TO-ROLL CONTACT
PRESSURE APPLIED PORTION
FORCES APPLIED FROM STRIP

FIG. 23

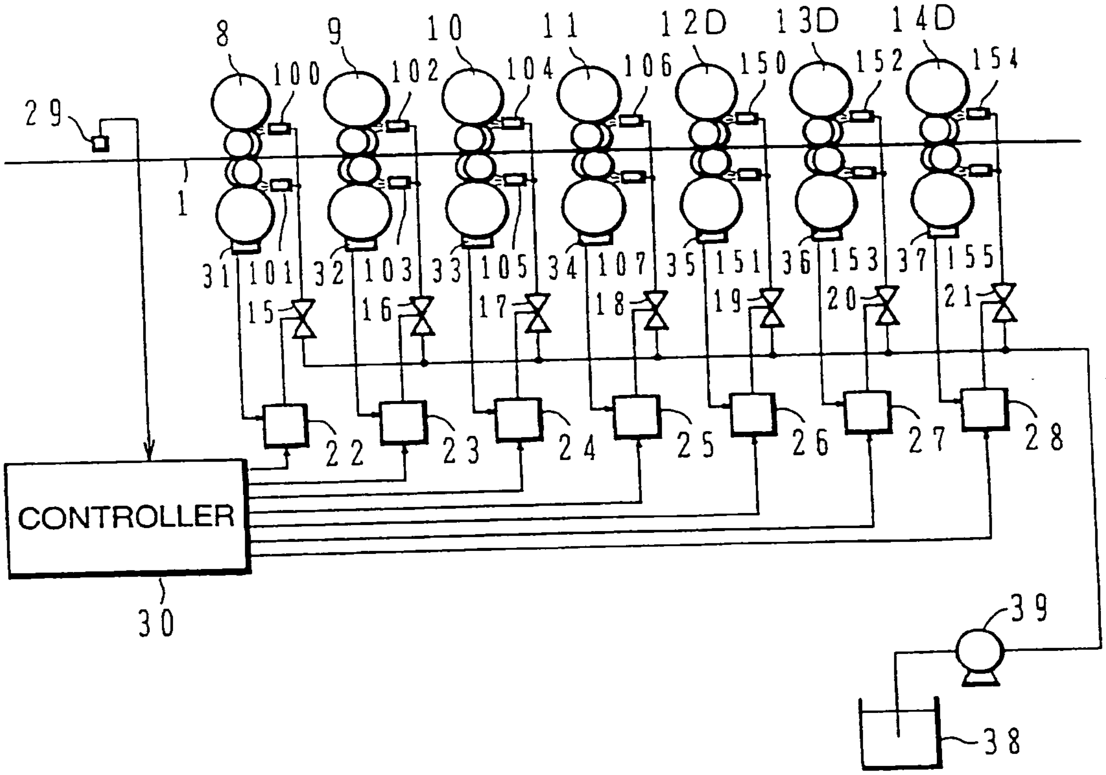
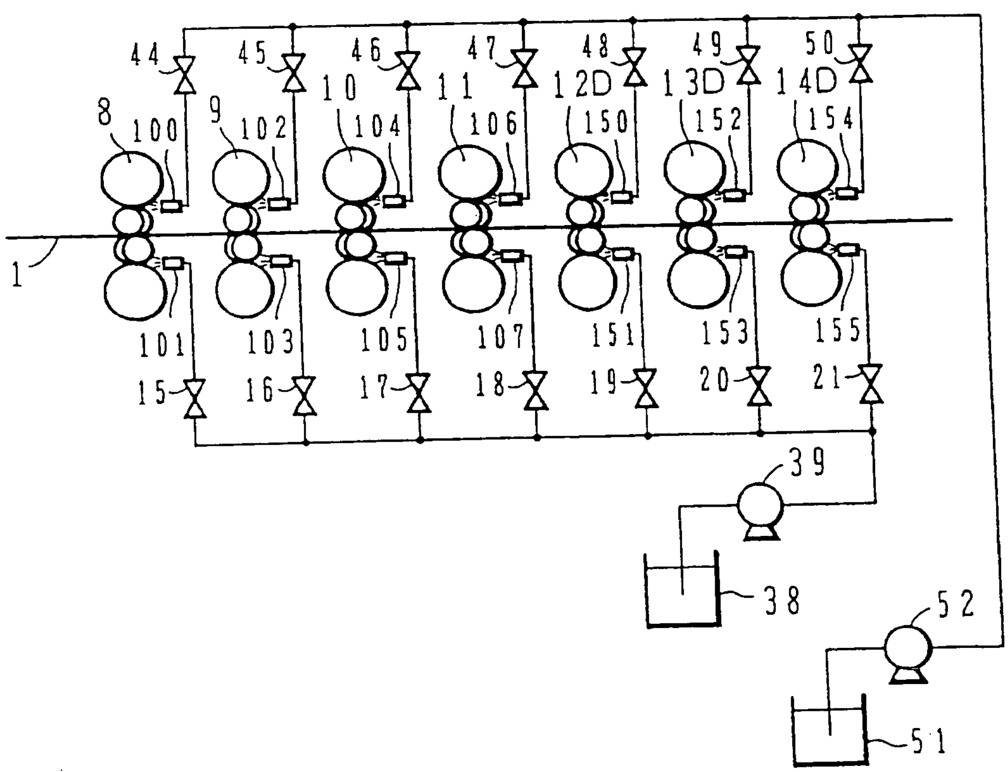

8
9
10
11
12D
13D
14D
100
102
104
106
150
152
154
29
1
31
101
32
103
33
105
34
107
35
151
36
153
37
155
15
16
17
18
19
20
21
22
23
24
25
26
27
28
CONTROLLER
30
39
38

FIG.25


44
45
46
47
48
49
50
8
9
10
11
12D
13D
14D
100
102
104
106
150
152
154
1
101
103
105
107
151
153
155
15
16
17
18
19
20
21
39
38
52
51

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 10 2313
Page 2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 276 743 (HITACHI LTD) * column 5, line 40 - column 6, line 6 * * column 7, line 47 - line 56 * * column 8, line 9 - line 17; claims 4,5; figures 1,6,7 *	1,3,4-8	
P,A	EP-A-0 506 138 (HITACHI LTD) *the whole document*	1-4,9, 10,19	
A	US-A-3 208 253 (W.L. ROBERTS) *the whole document*	9,10	
A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 145 (M-1233)10 April 1992 & JP-A-40 04 916 (NIPPON STEEL CORP) 9 January 1992 * abstract *	9,11-13, 20-22, 27,28	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 269 (M-259)(1414) 30 November 1983 & JP-A-58 148 009 (SUMITOMO KINZOKU KOGYO KK) 3 September 1983 * abstract *	11, 16-18, 20,25-27	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 14 (M-52)(686) 28 January 1981 & JP-A-55 144 311 (HITACHI SEISAKUSHO KK) 11 November 1980 * abstract *	11-15, 20-24,27	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06 MAY 1993	LILIMPAKIS E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document